

Fruit characteristics of *Actinidia* cultivars obtained at the M. Grishko National Botanical Garden of the Ukrainian NAS in Kyiv

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Abstract: *Fruit characteristics of Actinidia cultivars obtained at the M. Grishko National Botanical Garden of the Ukrainian NAS in Kyiv.* This paper summarizes the results of introduction and selection of *Actinidia arguta* (Siebold et Zucc.) Planch. ex Miq and its hybrids at the M. Grishko National Botanical Garden of the National Academy of Sciences of Ukraine in Kyiv. The main goal of the breeding program was to improve fruit quality, plant productivity, and winter hardiness. Pomological and biochemical analysis of the fruit of new cultivars was conducted in the years 2013–2015. The fruits of the best cultivars accumulated large amounts of vitamin C, sugars, organic acids and carotenoids, and have a high level of dry soluble substances. The yields of the cultivars described here were between 9 and 35 kg per plant. The tested cultivars were divided into four groups according to fruit maturation time. The best cultivars expressed good fruit characteristics and yield, and hence can be successfully cultivated on commercial plantations and in private gardens. They are also a good material for further breeding programs.

Key words: kiwiberry, selection, introduction, vitamin C, carotenoids, yield

INTRODUCTION

Expanding the range of fruit and ornamental plants through new types and forms is essential for the cultural enrich-

ment of phytocenoses. The continuing deterioration of the environment makes it necessary to find and mobilize plants with increased resistance and vitality, which include woody vines of the genus *Actinidia* Lindl. According to the latest revision the *Actinidia* genus includes 75 taxa [Ferguson and Huang 2007] and covers a closed area in Asia (China, Japan, Nepal, Sakhalin island, far eastern Russia). The vast majority of species of *Actinidia* are decorative vines, but some of them are very important fruit plants. These include primarily *Actinidia deliciosa* (A.Chev.) C.F. Liang et A.R. Ferguson, which currently provides one of the most valuable fruit exports (“kiwifruit”). In regions with temperate climates and cold winter the main attention is focused on frost-resistant actinidia species characterized by high adaptive possibility and productivity – *A. kolomikta* (Rupr. et Maxim.) Maxim., *A. arguta* (Siebold et Zucc.) Planch. ex Miq. Lately *A. arguta* (called hardy kiwifruit or kiwiberry) has come to be seen as a promising commercial culture in many countries, including New Zealand, the USA, Japan, Poland, Belgium, Germany and others

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[Latocha 2010]. Unfortunately, there are no commercial plantations of *A. arguta* in Ukraine, but many promising varieties of *Actinidia* for commercial cultivation have been selected.

In Ukraine, the investigation of cold-resistant species of *Actinidia* was initiated by academician M. Kaschenko in 1914, and systematic research concerning the formation of a collection of *Actinidia* for further selection work was started at the M. Grishko National Botanical Garden (NBG) of the National Academy of Sciences of Ukraine in 1958. Today, that institution has the largest collection of actinidia in Ukraine, which is constantly replenished by exchange with various botanical institutions and through breeding work, which is aimed at creating high-performance varieties adapted to the conditions of the Ukrainian forest steppe. The collection comprises 6 species and over 300 different taxa of actinidia. It includes *A. arguta*, *A. kolomikta*, *A. arguta* var. *purpurea* (Rehder) C.F. Liang ex Q.Q. Chang, *A. polygama* (Siebold et Zucc.) Maxim., *A. deliciosa*, *A. macrosperma* C.F. Liang and *A. callosa* Lindl. The 15 cultivars of “hardy” actinidia appear in the Register of Plant Cultivars of Ukraine. Therefore, the aim of this study was to determine some external and internal fruit quality traits of new *Actinidia* cultivars obtained at M. Grishko NBG.

MATERIAL AND METHODS

National Botanical Garden (NBG) is located in the southern part of Kyiv, on the Kyiv Elevation, and its area is geomorphologically associated with the large

Dnieper Elevation. The main type of soil is dark gray ash. The soil surface is very blurred and has low humus content. The climate of the area in which Kyiv is located is moderately continental with average annual temperature 9.4°C. Studies were conducted in the years 2013–2015. Analysis was performed on 15-years-old plants. As material for pomological investigation, actinidia fruit in the state of consumer maturity were chosen (based on fruit softness). The weight, length and width of the fruit were measured on 100 randomly chosen fruits of each cultivar. The mass fraction of dry soluble substances was determined by a refractometric method [GOST 28562-90, 1990]; acidity in terms of citric acid was determined by titration with 0.1M NaOH [GOST 23555.0-82, 1984]; ascorbic acid content by an iodometric method [Pleshkov 1976]; total sugars by the ferricyanide method [GOST 8756.13-87, 1988]; and total carotenoids spectrophotometrically [GOST 8756.22-80, 1981]. The chemical analyses were performed each year on 50 randomly chosen fruits of each cultivar.

RESULTS AND DISCUSSION

The introduction of actinidia at NBG was initiated by sowing free pollination seeds, obtained from the botanical gardens of Beijing (China), Lviv (Ukraine), Batumi (Georgia) and Michurinsk (Russia). As a result of selection of the most promising forms, new frost-resistant cultivars of actinidia named ‘Sentiabrskaya’ and ‘Purpurnaya Sadovaya’ were obtained. Next, they were used in a breeding pro-

gram to obtain new cultivars, which are characterized by stable annual crop, diverse biochemical fruit properties and frost resistance. For this purpose the hybridization of *A. arguta* and *A. arguta* var. *purpurea* was conducted, and then among the hybrid material the cultivars 'Figurnaya', 'Kievskaya Krupnoplodnaya' and 'Kievskaya Gibridnaya' were selected [Shajtan et al. 1983]. Due to this stage of the selection process, highly winter-hardy cultivars with high fruit quality, i.e. 'Nadiya', 'Originalnaya', 'Lasunka', 'Perlyna Sadu', 'Krasunia', 'Smaragdova' and 'Juvileyna', were released. The following fruit selection criteria were used: fruit size and taste, time of maturation, and yield. Finally, 15 cultivars of *A. arguta* were obtained and officially registered [Klimenko and Skrypchenko 2013]. For the pollination of all Ukrainian cultivars of *A. arguta* the pollinator cultivar 'Don-Juan' was selected. 'Don-Juan' is characterized by a long flowering period and high level of pollen fertility.

The average fruit weight depended on cultivar and ranged from 5.55 to 18.5 g (Table 1). Fruit weight remained at a similar level in successive harvest years. The fruit differ in shape and color (Fig. 1). The 'Kievskaya Krupnoplodnaya', 'Originalnaya', 'Nadiya', 'Zagadkova', 'Juvileyna' and 'Smaragdova' cultivars produced the largest fruits. The average kiwiberry yield per plant ranged from 9 to 35 kg. The cultivars with the highest yields were 'Purpurnaya Sadovaya', 'Kievskaya Krupnoplodnaya', 'Zagadkova' and 'Rima'. Depending on the fruit ripening time, the

cultivars were divided into (a) very early ripening – 'Perlyna Sadu' (fruits ripen in late August); (b) early ripening – 'Figurnaya' and 'Lasunka' (fruits ripen in early September); (c) medium ripening – 'Kievskaya Krupnoplodnaya', 'Sentjabrskaya', 'Kievskaya Gibridnaya', 'Originalnaya', 'Zagadkova', 'Rima', 'Originalnaya' and 'Rubinovaya' (in the Ukrainian forest steppe fruit ripening lasts from September 15 to 25); and (d) the latest cultivars – 'Purpurnaya Sadovaya' and 'Karavaievskaya Urozhainaya' (fruits ripen from late September to early October).

The fruit chemical composition was mostly determined by the cultivar. However, differences between successive years indicate that fruit internal quality could also be affected by weather and soil conditions, as well as fruit ripeness at harvesting. Titratable acidity and sugar content of the analyzed fruit are shown in Table 2, and dry matter, vitamin C and carotenoid contents are presented in Figures 2–4. Large variations in the studied parameters were recorded. Depending on cultivar, dry matter (DM) content varied from 13.7 to 17.5%. The highest DM values were obtained for 'Lasunka', 'Figurnaya' and 'Perlyna Sadu'. The titratable acidity ranged from 0.37 to 0.76%; 'Krasunia' and 'Figurnaya' had the lowest acidity and 'Kievskaya Gibridnaya' and 'Karavaievskaya Urozhainaya' the highest. The sugar content varied between 4.27% ('Zagadkova') and 11.97% ('Purpurna Sadova'). The highest vitamin C content, above 100 mg·100 g⁻¹ FW, was recorded for 'Kievskaya Gibridnaya' and 'Originalnaya'. For the

TABLE 1. Morphological characteristics of *Actinidia* cultivars from NBG selection in successive years of the study. The values are means (\pm SD, n = 100)

Cultivar (parents)	Fruit weight (g)			Fruit length (cm)			Fruit width (cm)			Average yield (kg/plant ⁻¹)
	2013	2014	2015	2013	2014	2015	2013	2014	2015	
'Purpumaya Sadovaya' (<i>A. arguta</i> var. <i>purpurea</i>)	11.31 \pm 1.54	10.63 \pm 0.96	11.66 \pm 1.43	3.47 \pm 0.15	3.75 \pm 0.27	3.29 \pm 0.14	2.27 \pm 0.14	2.22 \pm 0.12	2.32 \pm 0.09	20–35
'Sentiabrskaya' (<i>A. arguta</i>)	9.02 \pm 0.99	8.84 \pm 0.91	10.34 \pm 1.78	2.88 \pm 0.09	2.93 \pm 0.12	2.38 \pm 0.11	2.45 \pm 0.12	2.24 \pm 0.09	2.57 \pm 0.15	9–12
'Krasnaya' (<i>A. arguta</i>)	12.95 \pm 1.03	13.04 \pm 0.85	13.31 \pm 1.22	2.62 \pm 0.12	2.51 \pm 0.13	2.58 \pm 0.18	3.21 \pm 0.18	2.84 \pm 0.14	2.77 \pm 0.15	9–12
'Kievskaya Gibrinaya' (<i>A. arguta</i> \times <i>A. arguta</i> var. <i>purpurea</i>)	9.75 \pm 1.32	9.05 \pm 1.17	10.61 \pm 1.84	2.77 \pm 0.18	2.80 \pm 0.25	2.92 \pm 0.19	2.48 \pm 0.11	2.39 \pm 0.16	2.45 \pm 0.18	10–18
'Kievskaya Krupnoplodnaya' (<i>A. arguta</i> \times <i>A. arguta</i> var. <i>purpurea</i>)	16.65 \pm 2.03	17.95 \pm 1.01	18.50 \pm 2.42	3.48 \pm 0.10	3.71 \pm 0.12	3.37 \pm 0.19	3.12 \pm 0.23	3.07 \pm 0.13	2.87 \pm 0.14	20–25
'Figumaya' (<i>A. arguta</i> \times <i>A. arguta</i> var. <i>purpurea</i>)	7.84 \pm 1.19	6.95 \pm 0.82	8.61 \pm 1.44	2.55 \pm 0.10	2.35 \pm 0.12	2.9 \pm 0.15	2.15 \pm 0.19	2.31 \pm 0.13	2.08 \pm 0.20	15–20
'Rima' ('Sentiabrskaya' \times <i>A. arguta</i> var. <i>purpurea</i>)	6.87 \pm 0.54	7.21 \pm 0.84	6.83 \pm 1.51	2.59 \pm 0.14	2.60 \pm 0.20	2.61 \pm 0.15	2.11 \pm 0.09	2.12 \pm 0.06	2.13 \pm 0.06	15–20
'Zagadkova' ('Sentiabrskaya' \times <i>A. arguta</i> var. <i>purpurea</i>)	10.72 \pm 1.21	12.04 \pm 1.11	9.34 \pm 1.58	2.71 \pm 0.14	2.53 \pm 0.09	2.86 \pm 0.23	2.61 \pm 0.16	2.74 \pm 1.85	2.60 \pm 0.14	15–20
'Originalnaya' ('Sentiabrskaya' \times <i>A. arguta</i> var. <i>purpurea</i>)	10.34 \pm 2.41	10.11 \pm 1.46	10.45 \pm 1.95	3.26 \pm 0.29	3.33 \pm 0.20	3.01 \pm 0.19	2.20 \pm 0.23	2.34 \pm 0.15	2.24 \pm 0.17	15–20
'Lasunka' ('Sentiabrskaya' \times <i>A. arguta</i> var. <i>purpurea</i>)	8.73 \pm 0.86	8.05 \pm 0.95	9.32 \pm 1.32	3.19 \pm 0.14	3.29 \pm 0.11	2.29 \pm 0.20	2.08 \pm 0.12	2.15 \pm 0.09	2.22 \pm 0.14	10–11
'Karavaievskaya Urozhainaya' ('Purpumaya Sadovaya' \times <i>A. arguta</i>)	5.55 \pm 0.84	6.12 \pm 0.86	6.63 \pm 1.09	2.54 \pm 0.09	2.64 \pm 0.14	2.32 \pm 0.13	1.82 \pm 0.18	1.75 \pm 0.14	1.86 \pm 0.12	10–12
'Nadiya' ('Purpumaya Sadovaya' \times <i>A. arguta</i>)	9.48 \pm 1.77	10.05 \pm 1.66	8.97 \pm 1.37	3.44 \pm 0.25	3.58 \pm 0.21	3.18 \pm 0.14	2.19 \pm 0.18	2.25 \pm 0.17	2.17 \pm 0.14	15–20
'Rubinovaya' ('Purpumaya Sadovaya' \times <i>A. arguta</i>)	6.43 \pm 0.73	7.01 \pm 0.97	6.06 \pm 1.03	2.99 \pm 0.14	2.85 \pm 0.10	3.16 \pm 0.15	1.89 \pm 0.11	1.74 \pm 0.15	1.95 \pm 0.13	10–13
'Perlyna Sadu' ('Purpumaya Sadovaya' \times <i>A. arguta</i>)	6.45 \pm 0.86	8.74 \pm 0.63	8.21 \pm 1.11	2.54 \pm 0.10	2.43 \pm 0.08	2.53 \pm 0.15	2.16 \pm 0.11	2.44 \pm 0.09	2.12 \pm 0.13	12–15
'Juvileyna' ('Kievskaya Krupnoplodnaya' \times 'Purpumaya Sadovaya' \times <i>A. arguta</i>)	14.52 \pm 2.04	13.25 \pm 0.58	14.83 \pm 2.13	3.63 \pm 0.21	3.47 \pm 0.08	3.73 \pm 0.15	2.61 \pm 0.14	2.33 \pm 0.06	2.56 \pm 0.11	12–15
'Smaragdova' ('Sentiabrskaya' \times 'Don-Juan')	11.52 \pm 1.63	9.78 \pm 1.07	10.20 \pm 1.84	3.28 \pm 0.14	3.40 \pm 0.26	2.92 \pm 0.17	1.85 \pm 0.15	2.13 \pm 0.08	1.72 \pm 0.10	12–15

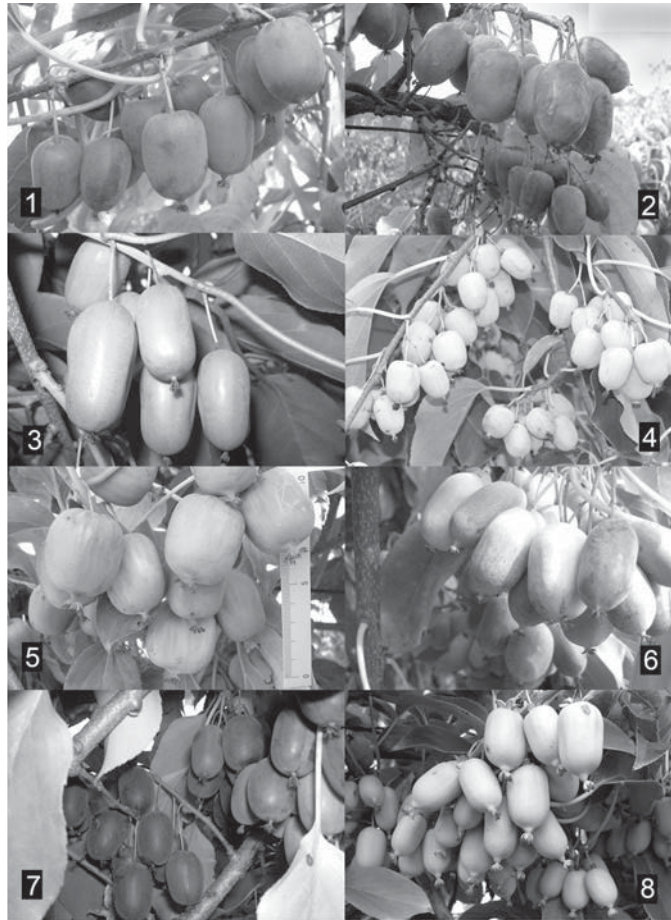


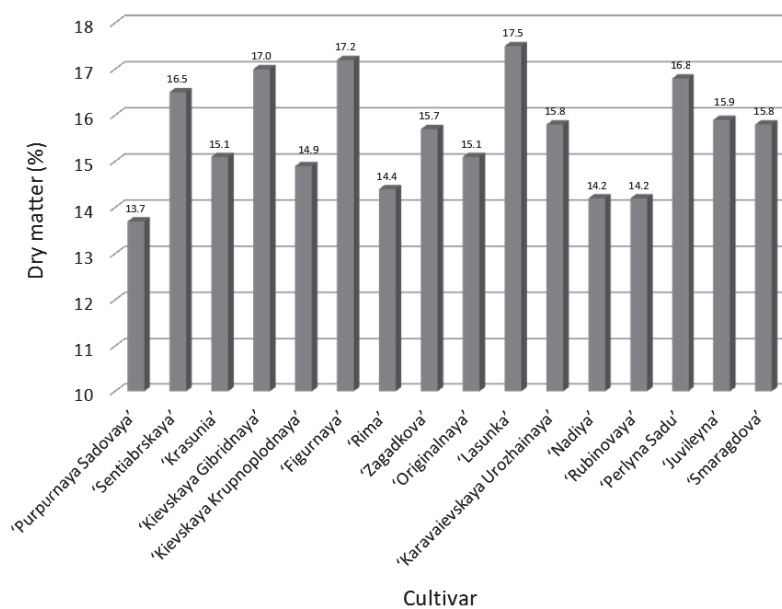
FIGURE 1. *Actinidia* cultivars obtained in Kyiv Botanical Garden: 1 – ‘Juvileyna’; 2 – ‘Purpurnaya Sadovaya’; 3 – ‘Smaragdova’; 4 – ‘Rima’; 5 – ‘Kievskaya Krupnoplodnaya’; 6 – ‘Rubinovaya’; 7 – ‘Nadya’; 8 – ‘Oryginalnaya’ (photo: N. Skrypchenko)

other cultivars, ascorbate concentration varied between 48.7 and 91.9 mg·100 g⁻¹ FW. Some of these cultivars have also been tested in Polish climatic conditions, giving comparable values of most of the above-mentioned traits [Bieniek 2012]. Compared with Ukrainian kiwiberries, those cultivated in Polish climatic conditions had considerably higher vitamin C content (above 100 mg·100 g⁻¹ FW for most of the tested cultivars).

The current stage of *Actinidia* selection work at NBG is directed towards obtaining new cultivars bearing fruit with greater pro-health potential, i.e. higher content of biologically active substances. These properties should be accompanied by high frost-resistance and high yield. The established collection of *Actinidia* cultivars and forms may serve as starting material for this purpose.

TABLE 2. Titratable acidity and sugar content depending on cultivar and harvest year. The values are means (\pm SD, n = 50)

Cultivar	Titratable acidity (%)			Total sugar (%)		
	2014	2015	2015	2013	2014	2015
'Purpurnaya Sadovaya'	0.90 \pm 0.08	0.42 \pm 0.04	0.54 \pm 0.05	6.76 \pm 0.57	11.97 \pm 1.05	6.62 \pm 0.71
'Sentiabrskaya'	0.32 \pm 0.04	0.63 \pm 0.06	0.41 \pm 0.03	7.59 \pm 0.69	5.56 \pm 0.59	8.03 \pm 0.73
'Krasunia'	0.30 \pm 0.03	0.39 \pm 0.04	0.48 \pm 0.04	8.20 \pm 0.72	7.34 \pm 0.68	6.51 \pm 0.56
'Kievskaya Gibrinaya'	0.88 \pm 0.07	0.64 \pm 0.05	0.76 \pm 0.06	7.23 \pm 0.58	6.91 \pm 0.40	7.07 \pm 0.65
'Kievskaya Krupnoplodnaya'	0.65 \pm 0.05	0.81 \pm 0.06	0.49 \pm 0.04	7.62 \pm 0.65	8.47 \pm 0.74	6.80 \pm 0.54
'Figurnaya'	0.28 \pm 0.03	0.46 \pm 0.04	0.37 \pm 0.03	10.01 \pm 0.95	10.36 \pm 0.89	9.72 \pm 0.83
'Rima'	0.49 \pm 0.04	0.45 \pm 0.04	0.53 \pm 0.04	11.31 \pm 1.04	12.26 \pm 1.09	10.36 \pm 0.98
'Zagadkova'	0.65 \pm 0.05	0.43 \pm 0.03	0.88 \pm 0.06	9.57 \pm 0.84	10.28 \pm 0.89	4.27 \pm 0.39
'Originalnaya'	0.91 \pm 0.08	0.47 \pm 0.03	0.49 \pm 0.04	7.37 \pm 0.68	7.45 \pm 0.69	8.76 \pm 0.74
'Lasunka'	0.77 \pm 0.07	0.62 \pm 0.05	0.72 \pm 0.06	7.80 \pm 0.69	10.88 \pm 0.84	8.20 \pm 0.68
'Karavaievskaya Urozhainaya'	0.78 \pm 0.06	0.51 \pm 0.04	0.88 \pm 0.07	8.75 \pm 0.77	9.95 \pm 0.86	9.64 \pm 0.88
'Nadiya'	0.71 \pm 0.05	0.52 \pm 0.04	0.76 \pm 0.06	8.40 \pm 0.71	5.46 \pm 0.42	7.95 \pm 0.62
'Rubinovaya'	0.32 \pm 0.03	0.21 \pm 0.02	0.96 \pm 0.08	9.40 \pm 0.83	10.22 \pm 0.87	8.20 \pm 0.64
'Perlyna Sadu'	0.75 \pm 0.06	0.38 \pm 0.03	0.55 \pm 0.04	9.91 \pm 0.84	9.40 \pm 0.72	9.64 \pm 0.73
'Juvileyna'	0.51 \pm 0.04	0.43 \pm 0.03	0.52 \pm 0.05	10.78 \pm 0.97	11.79 \pm 0.98	10.09 \pm 0.89
'Smaragdova'	0.44 \pm 0.04	0.42 \pm 0.03	0.49 \pm 0.04	9.20 \pm 0.87	9.64 \pm 0.81	8.76 \pm 0.74

FIGURE 2. Fruit dry matter content for *Actinidia* cultivars. Values are three-year averages

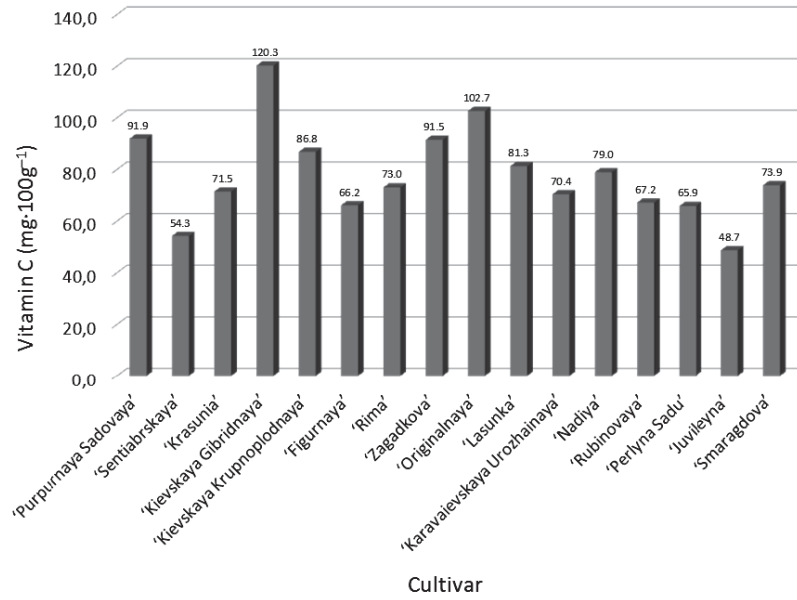


FIGURE 3. Fruit vitamin C content for *Actinidia* cultivars. Values are three-year averages

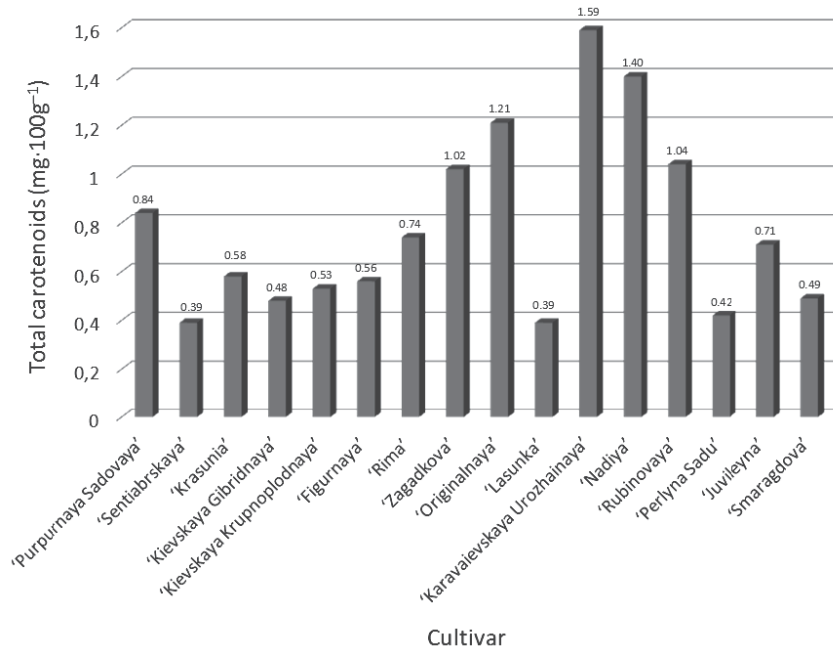


FIGURE 4. Fruit carotenoids content for *Actinidia* cultivars. Values are three-year averages

CONCLUSIONS

1. As a result of the introduction, acclimatization and selection of *Actinidia* at the NBG, a collection has been created including 6 species (*A. arguta*, *A. kolomikta*, *A. arguta* var. *purpurea*, *A. polygama*, *A. chinensis*, *A. macrosperma*, *A. callosa*) and over 300 different forms and cultivars. Fifteen of these cultivars have been entered in the Register of Plant Cultivars of Ukraine.
2. The average fruit weight of the selected cultivars ranged from 6.4 to 20.0 g, and the productivity of a 15-year-old plant ranged from 9 to 35 kg·plant⁻¹; the fruit ripening period lasted from late August until early October – practically for 2 months.
3. The fruit of NBG *Actinidia* cultivars had vitamin C, carotenoid and total sugar contents in the ranges 48–120 mg·100 g⁻¹ FW, 0.39–1.40 mg·100 g⁻¹ FW and 7.1–11.3% respectively.
4. It was concluded that the evaluated kiwiberry cultivars are able to compete with kiwifruit and other well-known fruits.

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Streszczenie: Charakterystyka owoców odmian aktinidii wyselekcjonowanych w Ogrodzie Botanicznym Akademii Nauk Ukrainy im. M. Grishko w Kijowie. Celem pracy była charakterystyka owoców nowych odmian aktinidii wyselekcjonowanych w Narodowym Ogrodzie Botanicznym im. M. Grishko Narodowej Akademii Nauk Ukrainy. Artykuł podsumowuje wyniki prac nad selekcją i introdukcją aktinidii ostrolistnej (*Actinidia arguta*) i jej mieszańców prowadzonych w Ogrodzie Botanicznym Akademii Nauk Ukrainy. Celem tych prac było uzyskanie odmian o lepszej jakości owoców, większej produktywności oraz lepszej mrozooporności. Badania pomologiczne oraz biochemiczne owoców prowadzono w latach 2013–2015. Owoce najlepszych odmian zawierały znaczne ilości witaminy C,

cukrów, kwasów organicznych, karotenu i miały dużą zawartość suchej masy. Plon poszczególnych odmian zawierał się w przedziale 9–35 kg z jednej rośliny. Poszczególne odmiany podzielono na grupy pod względem pory dojrzewania

owoców. Najlepsze odmiany mają owoce dobrej jakości, dają duży plon i mogą być z powodzeniem uprawiane na plantacjach towarowych oraz w ogrodach przydomowych. Mogą być także cennym materiałem do dalszej hodowli.